Regulatory Information Notice (RIN)

Supporting Information for Demand Management Innovation Allowance (DMIA)

2014-2015

August 2015
Prepared by Essential Energy

Contents

1 Introduction

The Demand Management Incentive Scheme (DMIS) applied to Essential Energy by the Australian Energy Regulator (AER) in the *Demand management incentive scheme for the ACT and NSW 2009 distribution determinations* (the Determination) aims to provide incentives for Distribution Network Service Providers (DNSPs) to conduct research and investigation into innovative techniques for managing demand so that in the future, demand management projects may be increasingly identified as viable alternatives to network augmentation.

The Demand Management Innovation Allowance (DMIA) is one component of the DMIS and is a valued element in enhancing the distributors' understanding of Demand Management tools and incorporating those understandings into business process. The following document outlines the specifics of Essential Energy's DMIA expenditure, the benefits of the projects and the outcomes achieved thus far.

2 Summary of Submission

Essential Energy's DMIA expenditure for the 2014/15 financial year largely consisted of the continuation of projects from previous years, with five different projects/programs in total including;

1. Continuation of the Grid Interactive Inverter program based on the 20kVA four quadrant inverter
2. Continuation of the Grid Interactive Inverter program based on the 5kVA four quadrant inverter
3. Continuation of Conservation Voltage reduction through the use of low voltage regulators
4. Capacitor Package Development
5. Switched Reactors

Total Program cost for the 2014/15 financial year is $502,741 with $502,741 allocated to CAPEX as follows;

Table 1 DMIA Expenditure 2014/15

Name of Project	Total amount of the DMIA spent in:		
	2014-2015		
	Operating expenditure ($ nominal)	Capital expenditure ($ nominal)	Total expenditure ($ nominal)
Grid Interactive Inverter program 5kVA based		$2,039	$2,039
Conservation Voltage Reduction through low voltage regulators		$205,728	$205,728
Switched Reactors		$294,974	$294,974
Capacitor Package Development		0	0
Grid Interactive Inverter program 20kVA based		0	0
Total		**$502,741**	**$502,741**

For further information refer to the specific project reports or contact dmcoordinator@essentialenergy.com.au

All costs are determined through the use of appropriate procurement systems and time recording.

2.1 Developments from previous years DMIA

Development during the regulatory period included:

- Switched Reactors: Site installations and commissioning complete.
- Conservation Voltage Reduction project through the use of low voltage regulators: Some of the specific site installations and commissioning complete.
- 20kVA and 5kVA Grid Interactive Inverter program: Optimised control techniques to maximise network support.
- Capacitor Package Development: Completion of standards and specifications to approach the market.

Knowledge gained from previous DMIA projects has allowed Essential Energy to provide a more cost reflective evaluation of demand management options within Essential Energy. This includes:

- The Energy and Network Capacity project has allowed Essential Energy to capture the long term costs of the inherently lumpy augmentation characteristics of network assets, in the past Essential Energy has struggled to implement demand management programs based on cost effectively deferring any single network element.
- The Energy and Demand audits project showed that substantial low cost demand management options are available, and as such Essential Energy is currently moving strategies into place to take advantage of the benefits found across power factor correction and pumping loads and moving toward further research into a number of other promising demand management options which still hold a degree of uncertainty such as standby generation, load shifting, load shedding and air conditioner efficiency.
- The Grid Interactive Inverter program highlighted the benefits of various inverter control techniques, specification requirements specific to Essential Energy's network and optimised control techniques to maximise network support. Since the commencement of the Grid Interactive inverter program a number of other suppliers have risen to deliver similar benefits, the evaluation of such emerging products and reduced costs in addition to the known benefits continues to permit cost reflective evaluation of demand management options within Essential Energy.

This renewed business case derivation for Demand Management was reflected in Essential Energy's most recent AER submission and will continue to be reflected in policy and project considerations.

3 Grid Interactive Inverter program – 20kVA four quadrant inverter

3.1 Summary

The grid interactive inverter program is a continuation of work undertaken in previous years under the DMIA to evaluate the many benefits available from four quadrant inverter technology.

3.2 Background information

An electricity network has real and reactive characteristics which interact with real and reactive power flows to determine the levels of voltage, current and losses around the network. The network's capacity to deliver load or absorb generation at any point can be constrained either by the current rating of elements in the supply path or by unacceptable voltage conditions for customers. Traditional network solutions involve augmentation to increase the supply capacity through upgrading existing infrastructure or providing additional infrastructure to reduce the impedance of the supply path.

A four quadrant inverter is capable of providing a combination of real and reactive power either into or out of the network. This capability can be used to adjust power flows and significantly improve voltages, currents and losses on the existing infrastructure as an alternative to network augmentation. The outcome will be improved utilisation of existing infrastructure and avoidance or deferral of network augmentation.

3.3 Grid Interactive Program overview

A development agreement was signed with an Australian electronics design and manufacturing company in December 2008 for the production of four prototype units, one for bench testing at their premises and three for a test installation on the Essential Energy network. Some of the preliminary development costs were incurred in the 2008/2009 financial year.

Figure 1 presents the test site that was established during 2009/2010 in Queanbeyan, adjacent to the Essential Energy Research and Demonstration Centre and an existing solar array, the prototype four quadrant inverters were installed in February 2010. There were significant network compatibility issues observed and the units were returned to the supplier for hardware and firmware upgrades to address them.

Figure 1 Queanbeyan Inverter Installation

The units were reinstalled in June 2010 and firmware adjustments continued through to 2nd September 2010 when network stability was achieved and proof of concept demonstrated. A workshop was held with the supplier in late September 2010 and design modifications agreed for a more robust unit and additional functionality for further field evaluation on the Essential Energy distribution network.

Field testing for the upgraded 20 kVA units began in January 2012 with the replacement of the original prototype units at Queanbeyan to check functionality. Figure 2 presents the results of the upgraded 20kVA units, with significant voltage improvement and inverter stability achieved. This was followed by installation of two three phase statcom field trials in the Bega area in February 2012, Figure 3 depicts the Bega area installations. Each of these statcom installations comprises three single phase, 20 kVAr inverters configured in statcom mode where the units provide coordinated reactive power support only and do not require a battery. Minor issues have been raised during these field trials which will continue to add positive development to the inverter program. The improved votlage profile achieved at a single site in Bega is presented in Figure 4.

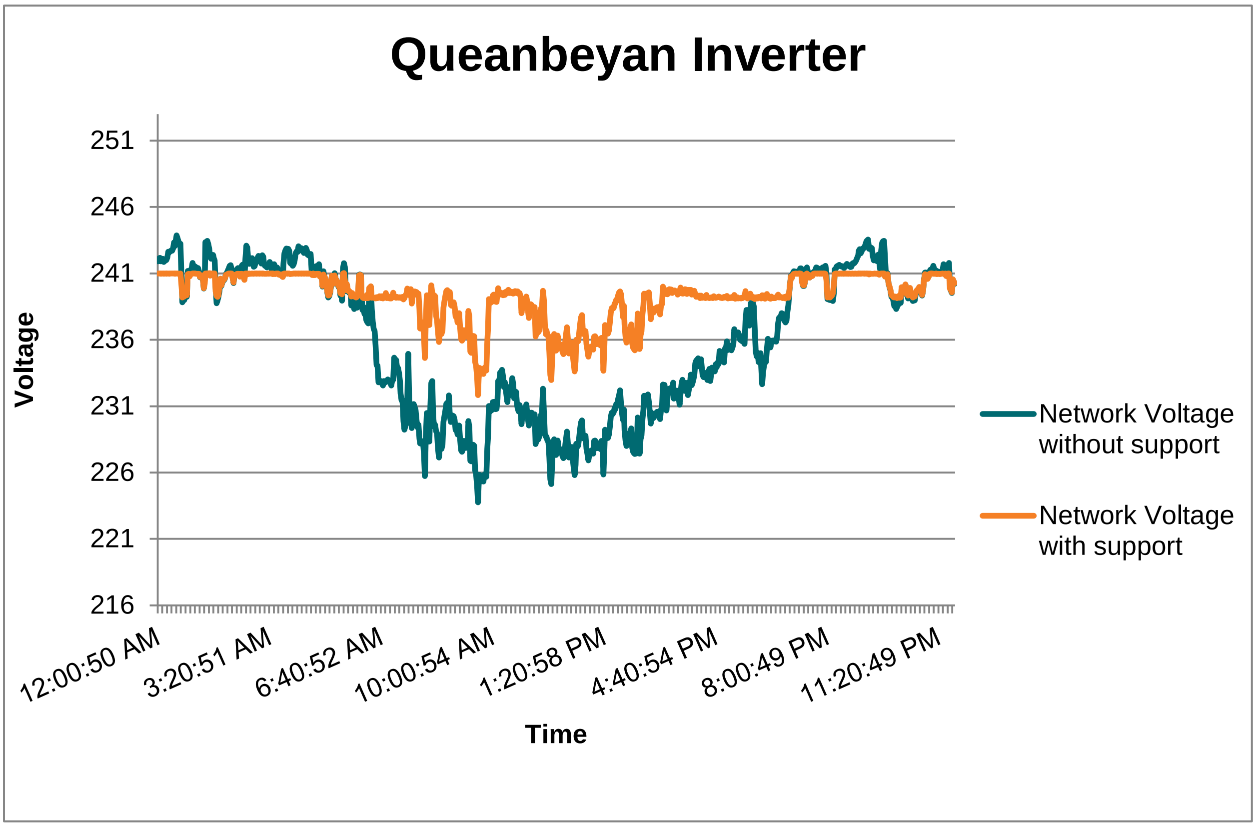


Figure 2 Queanbeyan Results as at July 2014

Figure 3 Bega / Kalaru Inverter Installation

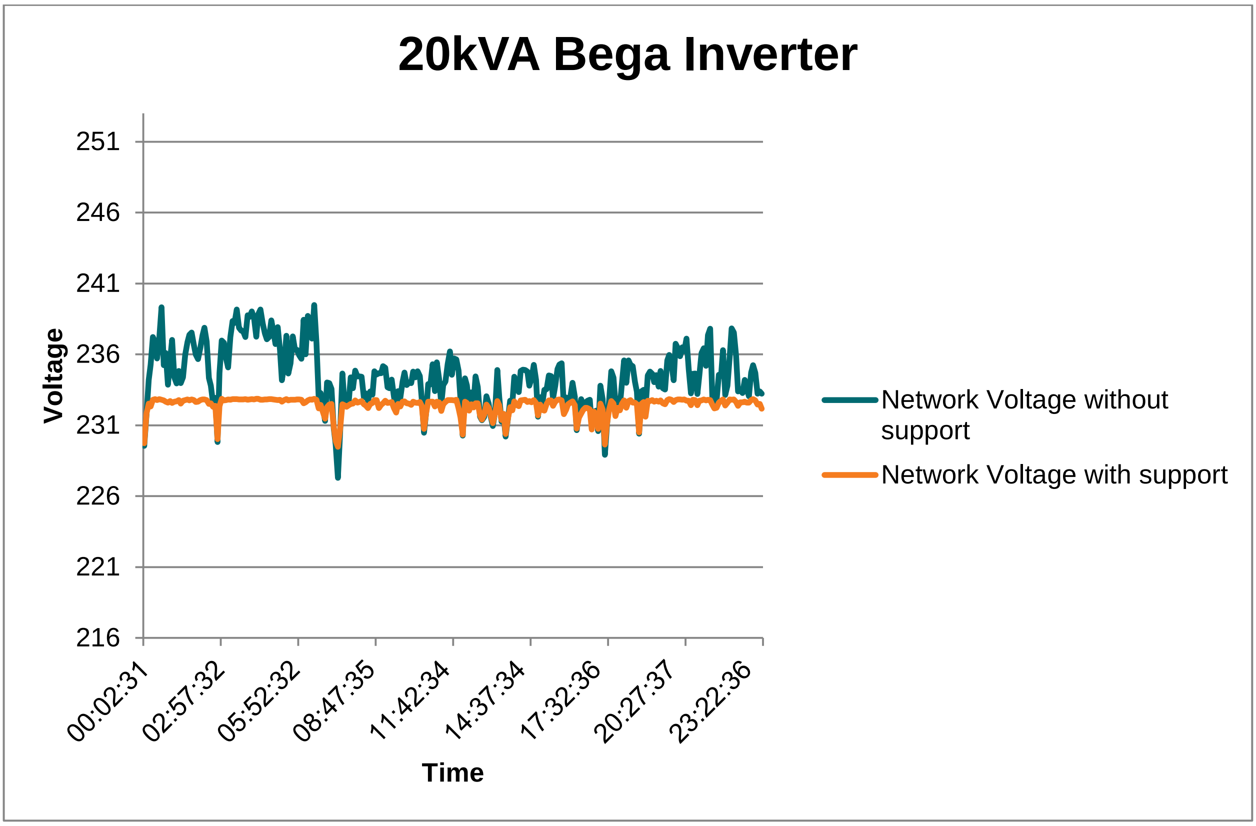


Figure 4 Bega Results as at July 2014

Figure 5 presents the Pappinbarra installation completed towards the end of 2012 where a single 20 kVA inverter and a lithium battery with 40 kWh of useable energy storage were installed on a single phase 11,000 volt feeder. Figure 6 presents the network voltage recorded with and without network support during August 2015.

Figure 5 Pappinbarra Inverter Installation

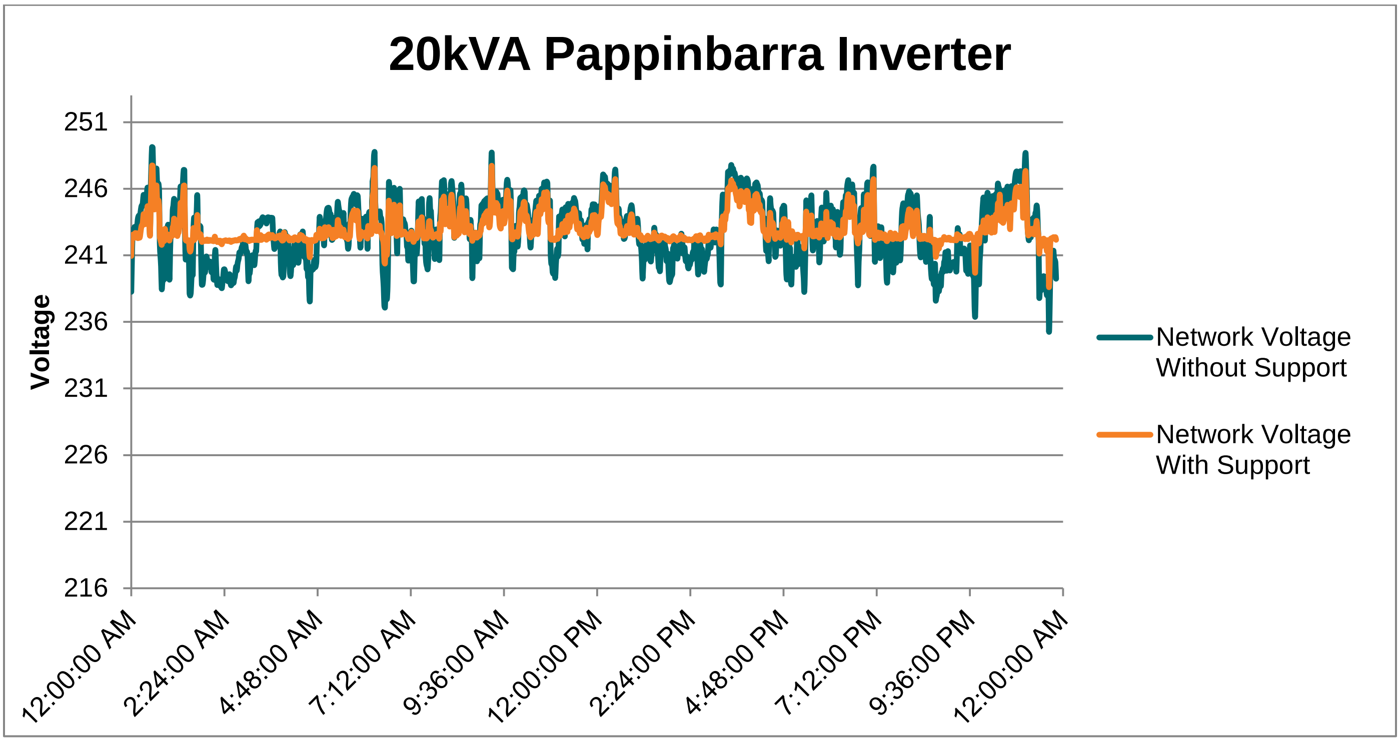


Figure 6 Pappinbarra Results as at August 2015

In 2013/14, monitoring, maintenance and some minor upgrades to the previously mentioned inverter installations continued. Essential Energy also worked on the development of a pole mounted version of the grid interactive version in order to develop a more cost effective installation type.

During 2014/15 Essential Energy worked with the manufacturer to improve the enclosure thermal rating for the 60kVA 3ph modular statcom unit, as an outcome of this some modifications have been requested, with the unit planned to be reinstalled and field tested early 2015/16.

Essential Energy has proven the voltage support benefits of the technology, and will continue to undertake work to define the value of the benefits available and engage with suppliers to determine the best course toward a business as usual operation.

3.4 Program Detail

The Grid Interactive inverter program involves research, development and field testing of four quadrant inverters as an enabling technology for energy storage and reactive power support which can be utilised to avoid or defer network augmentation in the low and medium voltage distribution networks. It is a continuation and expansion on Essential Energy's DMIA program from 2011-2014.

Individually the Grid Interactive Program consists of research, development and testing of the following configurations presented in Table 2.

Table 2: Grid Interactive Program

Project	Status	Description
60kVA 3ph modular statcom	Installed	A three phase modular statcom developed for a variety of uses as outlined under benefits, with particular focus on application to lines with high reactance to resistance ratios
60kVA 3ph energy storage and solar combination	Installed	A three phase statcom with energy storage used for development and testing of the optimum solar PV enabling technologies and routines
20kVA single phase modular statcom	Developed	A single phase modular statcom developed for a variety of uses as outlined under benefits, with particular focus on application to lines with high reactance to resistance ratios
20kVA single phase modular energy storage	Installed	A single phase modular statcom with lithium ion energy storage developed for a variety of uses as outlined under benefits, with particular focus on application to lines with low reactance to resistance ratios
Integration of Solar, Wind and Storage Systems into Distribution Grids for Network Support Study	Complete	The aim of this project is to develop a structured approach for infrastructure development to facilitate the integration of inverter-interfaced renewable energy resources and energy storage systems into electricity networks. With a focus on network support through: • Grid interactive inverters used for voltage regulation and power loss minimisation through control of active and reactive power; and • Design and analysis of graduated correction strategies associated with such systems.

3.5 Nature and Scope

The "Grid Interactive Inverter program based on the 20kVA four quadrant inverter" is a non-tariff based program to develop an enabling technology aimed at addressing specific network constraints by reducing demand on (including demand for generation export capacity) or providing reactive support to the network at the time and location of the constraint.

Four quadrant power electronics technology are currently used extensively in high power, high voltage network applications for static VAr compensation and large energy storage applications. During the initial stages of this program there was no low cost, commercially available similar technology for low power, low voltage or single phase systems, however semi-commercialised products have subsequently become available and these are continually assessed against the existing product to ensure the most efficient outcomes of the program.

Commercially available low voltage inverters are widely used for the connection of small scale renewable energy generation but their control methodology and design is currently not suited to full four quadrant grid interaction to facilitate network support.

3.6 Aims and Expectations

The aim of the program is to develop cost effective, flexible, low voltage, four quadrant inverters which can be used in a variety of applications to address a range of supply quality issues.

It is expected that final production cost for a single phase inverter will be in the order of $500 per kVA which compares favourably to commercially available small scale photovoltaic units offering substantially less functionality.

Energy storage costs are estimated to be $500 per kWh based on currently available lead acid technology, however it is expected that battery development for electric vehicles will ultimately provide a more cost effective alternative.

3.7 Selection

Essential Energy has a substantial rural distribution network, much of which was installed in the 1950s, 1960s and 1970s under various Rural Electrification Schemes using small section conductor on single phase and SWER construction in order to minimise cost to the customer. The capacity of these lines to supply load or absorb generation is limited.

Subsequent changes to system loads through “infilling” and increased demands of individual installations due to changes in lifestyle and price accessibility of electrical appliances has created many situations throughout Essential Energy where general voltage levels cannot be satisfactorily maintained within the allowable voltage range and short term fluctuations create increasing annoyance for customers.

Traditional network solutions include the installation of voltage regulators to address general voltage levels or conductor upgrades in situations where voltage regulation is not an effective option. Current costing for conductor upgrades can be in the order of $45,000 per km for SWER and $75,000 for single phase lines. Significant distances are also involved if an effective improvement in voltage conditions is to be achieved.

While the initial focus of the project was on a modular 20 kVA unit to address feeder level issues, the initial prototype installation demonstrated that the four quadrant capability can also be utilised for power quality improvement on low voltage systems. The low voltage installation is an effective means of mitigating voltage drops due to increased circuit loading or voltage rises due to increasing levels of small scale embedded generation. The scope of the program was subsequently extended to facilitate PV connection, VAr support and energy storage at residential level.

Low voltage network solutions include conductor upgrades or additional distribution substations. Depending on the circumstances this could typically cost between $20,000 and $200,000 to address a single constraint.

Initial options considered;

1. Traditional generation

   An alternative is to use an embedded generator at the end of the affected feeder to reduce the load the feeder needs to supply but traditional generators are often difficult to implement as they have issues with noise, pollution, security and maintenance.

2. Adaptation of commercially available inverter equipment

   The use of commercially available inverters as used for the connection of small scale wind and photovoltaic generation has previously been considered. A trial installation at Lake Mungo included Xantrex 4.5 kVA inverters at a unit cost of $6,300. Significant problems were experienced in adapting the inverter operation for interactive grid support with the final configuration and the units were not considered to be suited to further development due to the lack of a suitable grid interface.

3. High Voltage large scale equipment

High voltage inverters with grid interactivity are available from established companies however they are very expensive and not cost effective for low power applications required on weak rural feeders. Previous contact with these companies indicated that development of a suitable unit was not a high priority and any development costs would need to be recovered.

4. Develop a single phase, modular system (preferred option)

Identify a suitable partner and work with them to develop a specification and produce a prototype, modular power electronics system to provide real and reactive four quadrant operation for voltage support when used in conjunction with a suitable direct current source such as battery storage or renewable generation

3.8 Implementation

The project was broken into three distinct stages;

1. Knowledge acquisition phase

Prototype units were developed and installed in an environment where they could be closely monitored and design improvements checked for inclusion in the production version.

During the 10/11 financial year proof of concept was achieved with the prototype units installed at Queanbeyan and design modifications required for the production unit were agreed.

2. Field trial phase

First run production units were installed and their performance evaluated prior to approval for general use.

At the close of the 11/12 financial year substantial field trials and development towards a product suitable for general deployment were underway with final refinement work in progress in order to move the devices into the business as usual phase.

During the 12/13 financial year further monitoring and modification was made to the units to prepare them for general deployment.

3. General deployment phase

The utilisation of four quadrant inverters as a generic supply quality improvement technology on Essential Energy’s distribution network which may include development of incentive schemes to leverage spare network support capacity from suitable renewable energy connection equipment.

Essential Energy’s network and physical requirements on power electronic devices are fairly extreme, with temperatures in the network area ranging from 49.7°C to -23°C, as well as areas of high humidity, high levels of dust and salt spray. Essential Energy’s ideal installation locations can also be remote and difficult to access, resulting in rough transport conditions and minimal communications, electrically sites can be difficult, with spikes, sags and surges common, and a variety of frequency injection signals to contend with. These conditions have delayed the business as usual implementation of four quadrant inverters, however Essential Energy will continue to determine the most efficient means to achieve the benefits desired.

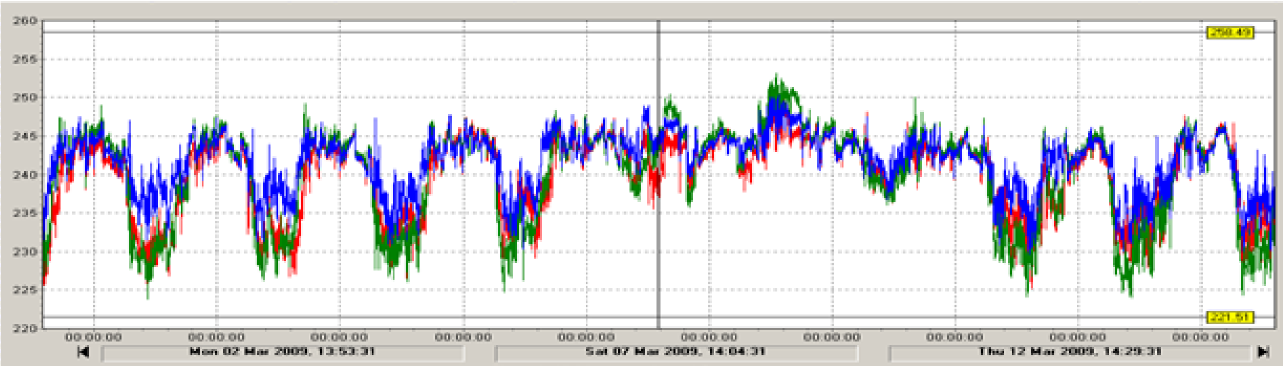
3.9 Benefits

Stage 1 of the project involved development and testing of prototype units and this was ongoing through 2009/2010. This was essentially a knowledge acquisition phase to observe the interaction of the prototype units under real network conditions and provide the basis for specification of a production unit.

Proof of concept was attained in 2010/2011 and design enhancements agreed for Stage 2 field trials, example results are shown in Figure 7.

WEEKLY VOLTAGE CHART

BEFORE – voltage range 253 to 224, Voltage unbalance 10V



AFTER – voltage range 248V to 234V, unbalance 5V
Normal voltage fluctuations still apparent away from 245V and 239V reactive power support levels

Figure 7 - Queanbeyan voltage monitoring

Network models were built and field projects designed to verify equipment functionality and provide the basis for development of the wider deployment strategy.

Three field trials commenced in 2012 with further refinements and developments required for business as usual operation.

The technology benefits have been proven in the field installations, however actual business benefits will accrue when the technology is field proven and deployed as an enabler for peak reduction and reactive power support applications to avoid or defer network augmentation.

Potential benefits and applications are provided in Table 3.

Table 3: Potential Benefits and Applications

Benefit	Application
Voltage pacification	Providing combinations of real and reactive power to keep voltages within a given range.
Real power support on long rural feeders	On high resistance circuits store energy at light load periods and release it at peak times to reduce voltage drop on the feeder.
Reactive power support	On high reactance circuits use either leading or lagging reactive power to raise or lower voltages as required.
Generation capacity enhancement	Use lagging reactive power to compensate for voltage rises caused by embedded generation.
Motor starting compensation	The fast (sub-cycle) response and short term rating of the inverter enables it to provide reactive power to balance the fluctuations due to starting of large motors.
Power factor correction	Providing reactive power to correct power factor - minimising line currents and losses.
Load and voltage balancing	Transferring real and reactive power between phases to ensure balanced supply conditions.
Conservation voltage reduction (CVR)	Controlling voltage levels to optimise energy usage and efficiency.
Loss reduction	Managing loading patterns to optimise network current flows for loss minimisation.
Energy storage (community, household, PV)	Balancing load and generation at local level to optimise network utilisation.
Microgrid operation	Operation as a fast response balance between generation and load to stabilise microgrid operation.
Peak price generation	Potential to store energy for release over peak price periods on the energy market to enhance asset value.
Peak lopping	Provide real power at peak periods to ensure network ratings are not exceeded.
Reliability improvement	Ability to operate in uninterruptible power supply (UPS) mode to improve voltage quality and sustain critical loads during power outages.
Local load control	Potential to act as a signal generator for local control applications.
Harmonic suppression	Acts as a “sink” for lower order harmonics through inductive coupling to the network.
Network monitoring	Current and voltage measurement at the point of application.

4 Grid Interactive Inverter program – 5kVA four quadrant inverter

4.1 Summary

The "Grid Interactive Inverter Program - 5kVA Four Quadrant Inverter" is a development from the 20kVA inverter program, as such much of this section will refer to the "Grid Interactive Inverter program based on the 20kVA four quadrant inverter". Summarily the 5 kVA grid interactive inverters were developed for use at residential level to support continued renewables generation connections without the adverse side effects currently seen in the distribution network.

4.2 Background information

Refer to section 3.2

4.3 Grid Interactive Program overview

Refer to Section 3.3

After initial developments within the 20kVA grid interactive program in 2010, it was determined that major contributions to the cost of the program and hence any future business as usual installations were;

- Relatively low volumes of devices being produced
- Installation costs

Opportunities also exist to use consumers own equipment/installations to provide reactive support and hence avoid "doubling up" of similar devices (i.e. residential inverters on the consumers side of the meter without reactive capabilities and four quadrant inverters on the network side of the meter), with the added benefit of providing greater distribution of the support (through smaller installation sizes).

To overcome the issues highlighted above and to work toward evaluation of the opportunities available a development agreement was signed with an Australian electronics design and manufacturing company in mid-2011 for the production of a number of 5kVA four quadrant inverters for testing purposes.

4.4 Nature and Scope

Refer to section 3.5

4.5 Aims and Expectations

For aims and expectations of grid interactive inverters, refer to section 3.6.

Specific aims and expectations relevant to the 5kVA inverter program were;

- A reduction in costs of grid interactive inverter technology
- A reduction in installation and maintenance costs with regard to grid interactive inverters
- An increase in the distribution of grid interactive inverters

4.6 Selection

Refer to section 3.7

Additionally;

1. 20 kVA grid interactive inverters

   20kVA grid interactive inverters offer many of the functional aims of the grid interactive project, however as highlighted in section 4.3 there were still a number of opportunities to improve on the cost effectiveness of the total installation whilst providing similar or greater benefits.

4.7 Implementation

The project has been broken into three distinct stages;

1. Knowledge acquisition phase

   Prototype units are developed and installed in an environment where they can be closely monitored and design improvements checked for inclusion in a production version.

   In 2012/2013 a number of 5kVA four quadrant inverters were delivered and tested to the proposed technical specifications and appropriate Australia Standards, as an outcome of this testing some modifications have been requested. During 2013/14 the 5kVA four quadrant inverters were returned to the manufacturer to complete the requested modifications. Throughout 2014/15 a number of units were upgraded and are now ready for deployment in further trials.

   Figure 8 presents the test site that was established at the Clearwater Zone Substation in Port Macquarie to perform longevity and functionality tests. It is evident from Figure 9 that this site performed near faultlessly with no known issues above what was raised during the initial testing.

Figure 8 - Clearwater Zone Substation 5kVA four quadrant inverter (atypical) installation

2. Field trial phase

First run production units are installed and their performance evaluated prior to approval for general use..

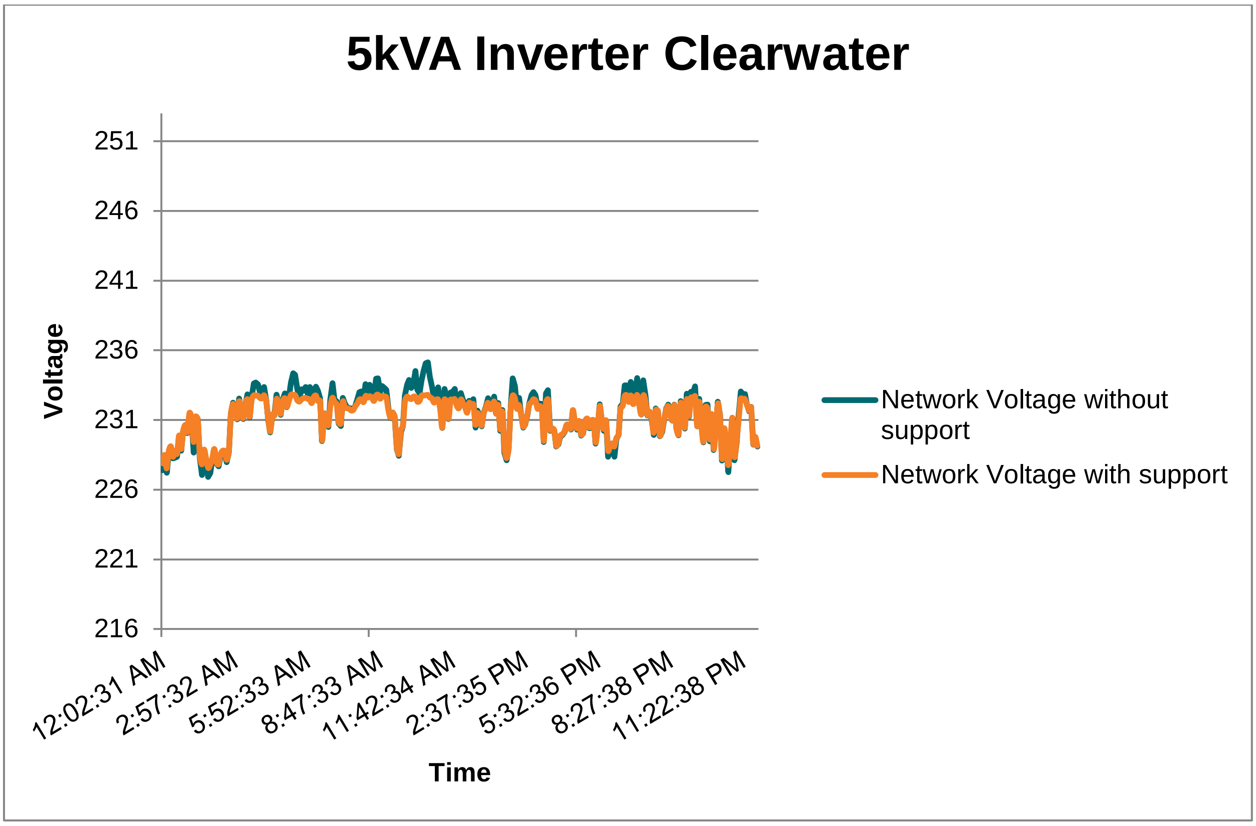


Figure 9 Clearwater 5kVA Inverter Results as at July 2014

3. General deployment phase

The utilisation of four quadrant inverters as a generic supply quality improvement technology on Essential Energy's distribution network may include development of incentive schemes to leverage spare network support capacity from suitable renewable energy connection equipment

4.8 Benefits

Actual business benefits will accrue when the technology is field proven and deployed as an enabler for peak reduction and reactive power support applications to avoid or defer network augmentation
Potential benefits and applications include those referenced in section 3.9;

5 Conservation Voltage Reduction through the use of low voltage regulators

Figure 10 - Low Voltage Regulator

5.1 Summary

The project "Conservation Voltage Reduction through the use of low voltage regulators" has been developed in order to;

- Evaluate the technical requirements and performance characteristics of conservation voltage reduction (CVR) in the Essential Energy network
- Build Essential Energy's technical knowledge for further development in the areas of power quality rectification, remote control, CVR and small scale generation
- Evaluate the reliability, usability and functionality of three phase low voltage regulators

5.2 Background information

Conservation voltage reduction (CVR) is a lowering of voltage at the customer connection point in order to increase end use efficiency, lower peak demand, lower energy use and decrease losses without adversely power quality. CVR is currently implemented in some commercial premises for financial benefit under the name of "voltage optimisation".

CVR is a relatively unused concept for most utilities due to a number of technical issues in its implementation. Instead CVR's main proponents are those in the energy efficiency sector.

The CVR factor (CVRf) is the percentage change in energy for a given percentage change in voltage i.e.

$$\frac{\% \Delta \text{ energy}}{\% \Delta \text{ voltage}}$$

The CVRf can also be expressed in terms of kW, kVAr demand reduction as;

$$\frac{\% \Delta X}{\% \Delta \text{ voltage}}$$

Where X is kW or kVAr, however unless explicitly stated CVRf refers to the change in energy.

Numerous studies have been completed on CVR with many stating the average CVRf for both demand and energy to be around 1.0 or slightly below. A CVRf of above zero is beneficial (ignoring fixed energy requirements) to a customer who is charged on kWh or on kW as any reduction in voltage, will decrease power. Figure 11 depicts an example of a CVRf test where a step change in voltage corresponds to a step change in power.

A CVRf of greater than one (i.e. where current decreases with voltage) or a negative CVRf (where voltage can be increased to decrease current) is required to be of direct benefit to a distributor whose lines and losses are related to current rather than energy or power. The addition of a voltage regulator provides a separation between the HV voltage levels and LV voltage levels and changes the interaction from the HV voltage to one of constant power.

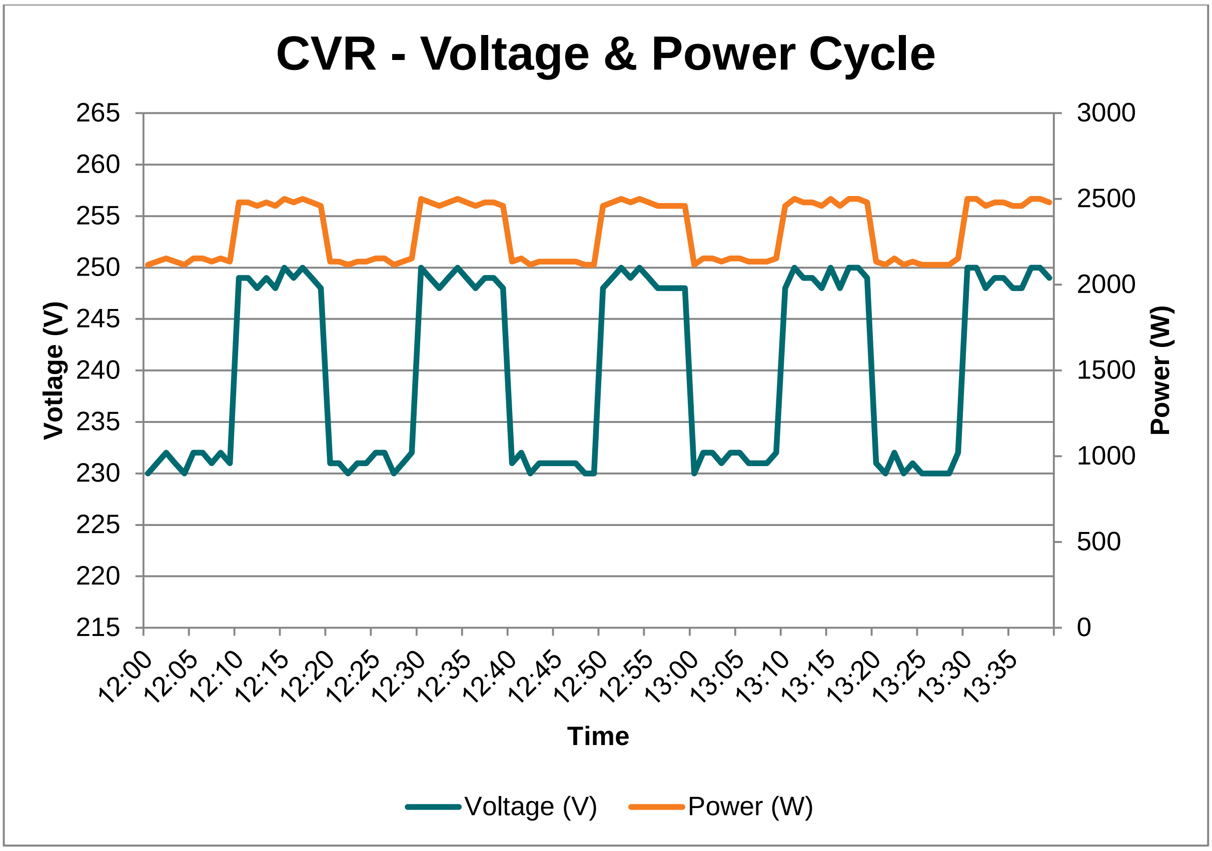


Figure 11 - Example CVRf test

5.3 Conservation Voltage Reduction through the use of low voltage regulators project overview;

The chosen device to investigate the CVRf theories outlined above is a three phase low voltage regulator, the benefits of using such a device are;

- Connected at LV, therefore trials can be small and with minor impacts to Essential Energy's business as usual operations
- The three phase regulator, once brought into the operational environment can be used in other sites for correction of voltage issues that would have required costly augmentation
- Allows the creation of a "constant power" LV network, thereby greatly improving the benefits of CVR over a HV controlled CVR implementation

Whilst the main aim of the project is a thorough understanding of CVR, CVRf and its implementation (innovation), the project has a secondary aim of evaluating the three phase regulator for business as usual use (building of capability) and determining the value of CVR when the regulator is used as a secondary function With this in mind it is planned that the Conservation Voltage Reduction through the use of low voltage regulators project will consist of the following;

- One three phase low voltage regulator installed for testing of CVR in a residential area
- One three phase low voltage regulator installed for testing of CVR in a commercial area
- One three phase low voltage regulator installed for testing of CVR in an industrial area
- Five three phase low voltage regulators installed for evaluation as a business as usual tool for voltage support, with CVR as the secondary consideration.

5.1 Nature and Scope

The Conservation Voltage Reduction through the use of low voltage regulators project is a non-tariff based project with the following objectives;

- Evaluation of the technical requirements and performance characteristics of conservation voltage reduction (CVR) in the Essential Energy network
- Building Essential Energy's technical knowledge for further development in the areas of power quality improvement, remote control, CVR and small scale generation
- Evaluation of the reliability, usability and functionality of three phase low voltage regulators

To complete the above objectives, the project will include the acceptance and functionality testing of a three phase low voltage regulator (in both voltage support and CVR functions), to determine the business as usual cost effectiveness (i.e. the calculation of total installed cost and benefits) of the product and bring the documentation around the product up to the level required for business as usual use. Given these desired outcomes the low voltage regulator development and testing will be limited to the following;

- CVR functionality
- The physical installation
- The configuration
- The operational aspects
- The network impacts
- The total known package costs
- Internal standards for installation and maintenance
- Education on product use

While testing development is to be limited to the above items, issues, risks and learnings will be unlimited in nature.

5.2 Aims and Expectations

The aim of the program is to test CVR at low voltage, in order to allow a separation between HV and LV voltages. Longer term, if successful, the completion of this project will allow Essential Energy to provide the business case for CVR at low voltage, and through previous research completed compare this to the benefits of CVR at HV, develop programs for the conservation of energy where economically viable, and defer network augmentation through either the reduction of demand through the use of CVR or the implementation of low voltage regulators to support the voltage at times of peak demand, with energy conservation as the secondary benefit.

5.3 Selection

Conservation Voltage Reduction is considered to be an effective tool in the conservation of energy, however for the reduction of network loads (current) ideally a separation between LV and HV voltages would exist to ensure the benefits of CVR are available in the HV feeder.

Initial options considered;

1. Single phase low voltage regulators

   Single phase low voltage regulators are already used by Essential Energy to maintain voltages in constrained areas. Essential Energy has a firm appreciation of the costs involved in these installations, and due to the relatively high installed costs compared to the small loads passed through the device (typically one or two customers) it is not considered economical to install single phase low voltage regulators for the primary use of implementing CVR. Additionally installation and data from the existing single phase low voltage regulator installations is atypical, as the short distance between the installed single phase regulators and the customers has meant that taking into account the voltage drop and losses between the regulator and the customer has not been a major issue.

2. The use of LV reactive compensation

   The use of low voltage reactive compensation can provide voltage regulation, but with the regulation comes the possibility of increased losses as power factor strays away from unity. It could be possible to constrain the reactive compensation in such a way as to ensure losses are not increased and that voltage regulation for the purpose of CVR is maintained, however the complexities and development involved would be far beyond what Essential Energy could hope to achieve in the timeframe scheduled for this project. The use of LV reactive compensation for voltage regulation in order to achieve CVR is not the preferred option at this stage, however it has been highlighted for consideration as a future project, should CVR prove economically viable under this project.

3. High Voltage Regulation

   High voltage regulation with the use of HV regulators and zone substation load drop compensation is already implemented on many of Essential Energy's feeders and high voltage distribution capacitors are in the initial stages of being used in business as usual situations. CVR for use in conserving energy can be implemented on some of these feeders provided monitoring or analytics are used, however in theory the peak current reductions for CVR on the HV feeder are minimal compared to using CVR on the low voltage side, that said the cost should also be significantly less, it will be part of learnings of this project to determine whether, given the differences in benefits achieved at HV and LV where CVR is most cost effective to implement.

4. Distribution Transformer regulation

   HV transformers use on-load tap changers to regulate voltage at the zone substation or on the HV feeder. On-load tap changers require a degree of maintenance and monitoring to ensure adequate operation and lifetime. The costs involved with this work and the additional capital cost of on-load tap changers has largely precluded their use on distribution transformers, however recent developments claim maintenance free on-load tap changers for distribution networks offering a potential opportunity for future CVR implementation. Essential Energy currently has in service approximately 130,000 distribution transformers which would likely rule out any large scale roll-out, nor would not be considered to be cost effective to remove and replace transformers for the trial period. However as a transformer requires an upgrade or reaches the end of serviceable life, then it may be cost effective to replace it for the purposes of CVR, if this project proves successful the business case for regulating low voltage transformers will be evaluated.

5. Low Voltage 3ph regulators

Low voltage regulators provide the decoupling between LV and HV voltages required for the optimal demand reductions (current). It is estimated that low voltage three phase regulators will provide a greater benefit/cost ratio than a single phase regulator due to the increased capacity for load being serviced and similar requirements for installation. Low voltage regulators will allow all objectives to be met with minimal intrusion into business as usual systems and therefore lower costs, low voltage regulators are also predicted to have business use outside of this project in deferring voltage constraint based augmentations. Therefore this is the preferred solution.

5.4 Implementation

The project has been broken into three distinct stages;

1. Knowledge acquisition phase

The units were installed in a workshop environment to permit completion of type tests, creation of site designs, unit settings, and integration of remote monitoring and control equipment to Essential Energy's SCADA system. During this phase of the project substantial development of the product with the manufacturer was undertaken, with a number hardware and software design revisions made due to the multitude of issues experienced with the operation of the technology. This work was completed late 2014/15, with the remaining units now ready for field installation.

2. Field trial phase

Three units are to be installed in field locations experiencing voltages at the higher end of the acceptable range, thereby allowing the greatest improvement and measurement of CVR potential. These installations will be across three load types of commercial, residential and industrial. During 2014/15 the commercial site was installed and commissioned, with the remaining two sites planned for completion by mid 2015/16.

Five units will be installed in field locations suffering from voltages outside of the acceptable range as this best represents the business as usual use for low voltage regulators. The potential for implementation of CVR will be measured and the benefits calculated. During 2014/15 four units were installed and commissioned, with the remaining site planned for completion by mid 2015/16.

3. Business as usual readiness

At the completion of the field trail conclusions will be drawn on the effectiveness of CVR in the Essential Energy area, and of the three phase regulator as a cost effective means of performing the CVR function. If the business case proves viable further evaluation will be undertaken to ensure the most cost effective implementation of CVR.

Finally an evaluation on the three phase regulator installations will ensure any issues or risks raised during the project are addressed before claiming the specific device as business ready.

5.5 Benefits

Due to the project being in the initial stages, minimal project benefits have been delivered, however a number of anticipated benefits are highlighted below;

- Knowledge acquisition in the area of conservation voltage reduction
- Evaluation of the potential for conservation voltage reduction as a secondary benefit in business as usual operation
- Avoided network augmentation through reducing/limiting peak demand and improved power quality
- Increased end use efficiency and equipment life
- Decreased network losses
- Facilitating the integration of distributed generation into the grid
- 3 phase voltage balancing
- Improved power factor
- Improving network visibility via remote monitoring and control

6 Capacitor Package Development

Figure 12 - Pole Top Capacitor

6.1 Summary

The Capacitor Package Development project was initiated based on the outcomes of a trial pole top capacitor bank project completed in 2011/12. The 2011/12 pole top capacitor bank installation was used to alleviate a specific voltage constraint and in doing so defer capital investment, this trial was therefore considered to be outside of the DMIA.

The project "Capacitor Package Development" has been created in order to develop standards and guidelines for use of distribution pole top capacitor banks, such that a broad scale roll-out could be implemented in the future with a minimum of technical issues.

6.2 Background information

Distribution feeder capacitors are highly utilised assets for many utilities within the US power system, and are increasingly being used within Australia in order to;

- Supplement substation power factor correction: In brownfield substations it can be prohibitively expensive to install extra capacitor banks and breakers in order to reduce current on the subtransmission feeder, installing capacitor banks on the distribution network avoids these costs whilst also providing additional benefits due to its proximity to the load.
- Provide an alternative to substation capacitors: As above.
- Manage distribution voltage profiles: Capacitors provide a voltage boost by either supplying reactive power requirements closer to the load or by the capacitive Volt-Ampere-reactives (VArs) travelling through the network to upstream loads. Switched capacitors serve to regulate voltage on a feeder, having the ancillary benefit of reducing the number of operations of voltage regulators, both line and (to

a lesser degree) substation on-load-tap-changers. This reduces the required maintenance on both regulators and tap-changers.

> Increase network capacity: Figure 13 illustrates the extra capacity that can be released by correcting the power factor of a feeder, as an example if the power factor on the feeder at peak load is at 0.8, then an additional 25% of feeder real power thermal capacity is available (not including reduced losses or increased voltage).

> Reduce line losses: By cancelling the reactive power drawn by loads with low power factor, capacitors decrease the upstream line current required to supply these loads and significantly lower I^2R losses.

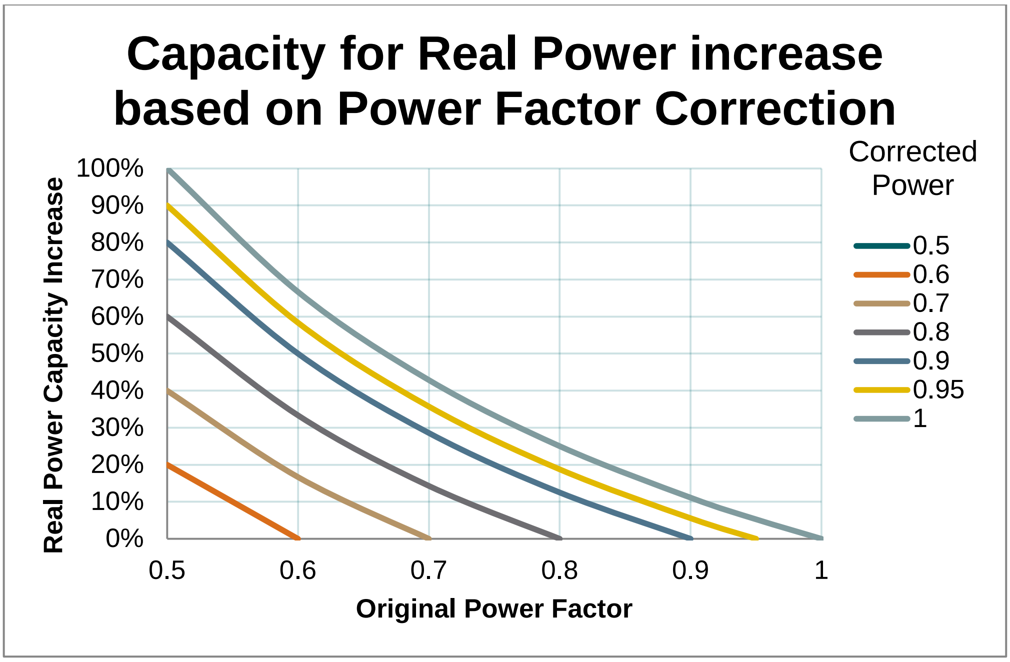


Figure 13 - Example of capacity increase through the correction of Power Factor

Simplified Theory of Capacitors

Capacitors work by storing energy. They are a relatively simple device; two metal plates sandwiched around an insulating dielectric. When charged to a given voltage, opposing charges fill the plates on either side of the dielectric. The strong attraction of the charges across the very short distance that separates the plates creates a strong electric field (electrostatic field) enabling the storage of energy. Having this field also means that capacitors oppose changes in voltage, hence it is also important to note that the charge on the plates does not change instantaneously; rather there is a time constant associated with charging and discharging capacitors.

In an AC power system capacitors don't store their energy very long – just one half cycle. As each half cycle a capacitor charges up and then discharges its stored energy back into the power system. The net energy (excluding losses) is zero. Every half cycle the capacitor will exchange reactive power with the (typically local) loads on the system that have a poor power factor. This benefits the system as the reactive power (seen as extra line current) does not have to be transmitted from the generators through kilometres of line and multiple transformers and this in turn frees up generators and upstream lines to generate and distribute greater amounts of real power.

Essential Energy's experience with Capacitors

Capacitors are installed, maintained and utilised within around 180 of Essential Energy's Zone Substations with relatively few issues, however the installation of distribution feeder capacitor banks within Essential Energy's network has been limited and sporadic. The reasons for the limited installation of distribution capacitor banks include;

- A number of potential issues that can arise if capacitor banks are incorrectly applied to the distribution network including;
  - Amplification of harmonics
  - Amplification/attenuation of frequency injection signals, this point is of considerable issue to Essential Energy due to the vast array of frequencies used in the installed frequency injection systems.
  - Switching transients (exacerbated historically by the number of single phase switches on the network)
  - Concern over leading power factors
  - Over voltages
  - Additional losses (where control settings are incorrect)
- A lack of understanding around the multitude of benefits of a distribution feeder capacitor installation and therefore underestimating the value of a capacitor bank installation during NPV analysis.
- A general lack of experience/knowledge in distribution capacitor banks, which creates a disincentive to install and an easy point of blame should any network issues arise (which will inevitably occur if the potential issues are not understood).

6.3 Capacitor Package Development overview

In 2011/12 a trial capacitor bank installation was completed at Clarencetown, confirming the expected costs and benefits and highlighting the outstanding issues for wider implementation. Subsequently the Capacitor Package Development project was created in order to overcome the remaining issues and provide the appropriate training and education for business as usual use.

Figure 14 - Clarencetown trial capacitor bank installation

6.4 Nature and Scope

The “Capacitor Package Development” project is a non-tariff based program to develop internal standards, guidelines and manuals for the use of power factor correction technology aimed at addressing specific network constraints by reducing demand on, or providing reactive support to the network at the time and location of the constraint.

The desired outcome for the “Capacitor Package Development” project is a robust package covering design, installation and operation which will allow the implementation of distribution capacitor banks across the Essential Energy network with minimal development on behalf of the end user. The robust package will include;

- Capacitor bank standard/s at various voltages and sizes (minimal variations)
- Maintenance plans
- Operational manuals
- Installation/specification manuals for use by the planning department
- Education of the end users (including planning and field staff)

6.5 Aims and Expectations

The aim of the “Capacitor Package Development” project is to develop a robust capacitor information package covering design, installation and operation which will allow the implementation of distribution capacitor banks across the Essential Energy network with minimal development on behalf of the end user. As HV distribution capacitors are already a mature technology, it is not expected that a great deal of cost reduction will occur in the future external to Essential Energy, however it is anticipated that internally there will be substantial cost reductions available as the final installed cost for distribution capacitors are expected to be under $100 per kVAr.

The low anticipated $/kVAr figure will allow for substantial cost effective voltage improvements on long lines and peak demand and loss reductions in poor to moderate power factor areas particularly in high loss distribution networks as shown in case study D8 of “Energy Efficiency Opportunities in Electricity Networks - Findings of industry trials for the extension of the EEO Program to network businesses” prepared by Energeia in consultation with the Department of Resources, Energy and Tourism.

6.6 Selection

There is little doubt that power factor correction is a cost effective alternative to network augmentation however there are quite a number of options on how to implement power factor correction for the greatest benefits and least cost. The options for installation of power factor correction were reviewed by Essential Energy as below;

1. Installation of capacitor banks at Zone Substation level

   Installation of capacitor banks at the zone substation is already undertaken by Essential Energy, however they can be cost prohibitive to upgrade in a physically constrained environment or to install in a brownfields site, on-top of this zone substation capacitors offer the least benefit of the possible options. Due to these cost implications it is proposed that Zone Substation capacitor bank installations occur only where substantial ancillary costs are not present, i.e. that Essential Energy continues to install power factor correction at zone substations where it is cost effective to do so, however alternatives offering greater benefits do exist with minimal cost implications, and hence this is not the preferred solution for this project.

2. Installation of pole-top distribution capacitors

   Installation of pole-top distribution capacitors provide substantial additional benefits over the zone substation installations, in demand reductions, voltage improvements and loss reduction, particularly on very long lines, whilst in theory the use of capacitors in pole-top configurations should not add greatly to the cost equation. This is the preferred solution.

3. Installation of distributor owned low voltage capacitors

Installation of capacitors on the low voltage system has the additional benefits of reducing losses and peak demand in the low voltage feeder, however by greatly decreasing the size of the load able to be connected off the capacitor (i.e. if 100% of load comes from the zone substation, 20% through any particular feeder and 1% through any particular distribution transformer by moving the installation to the distribution transformer we have decreased the reactive power flowing through the point of common coupling) we have greatly increased the number (and therefore cost) of installations required if we wish to avoid any adverse impacts. Due to these cost implications it is not proposed that distributor owned power factor correction be utilised in the low voltage network for bulk power factor correction at this stage, however should substantial developments occur that would alter the cost or benefit structure of the proposed solutions this should be re-evaluated.

4. Incentivising customers to perform their own power factor correction, through the use of tariffs and metering

Currently many of Essential Energy's customers pay for their customer classes' average impact on demand, hence price signals are for the most part blurred through the use of energy as a surrogate for demand, with some customers paying more than their fair share, and others paying less than their fair share.

By using price signals which relate relatively poorly to the cost of supply, manufacturers of end-use equipment and customers themselves have limited incentive to ensure that end-use equipment has a minimal impact on the network or the costs of the network. To avoid customers paying more or less than their fair share, and to provide an incentive to reduce overall network costs, ideally customers should pay for their true impact on the cost structure of Essential Energy's assets, i.e. customers would pay for the impact of their demand, in terms of kVA (both kW and kVAr).

Currently Essential Energy is not in a position to bring demand type pricing to the majority of customers, nor does it believe the majority of customers have enough understanding of power factor or its impacts on demand to respond appropriately, therefore this is not the preferred option at this point in time. The AER is beginning to regulate the above inequalities and lack of education through the implementation of the "Power of Choice" and as this regulation moves through to implementation Essential Energy will be able re-evaluate the potential of moving more customers to a position of greater cost reflectivity.

6.7 Implementation

The project has been broken into three distinct stages;

1. Knowledge acquisition phase

The multitude of issues relating to the use of distribution capacitors was researched and tabulated, along with the functional requirements of our internal process including switching, safety, SCADA and maintenance. This work was completed during the 2012/13 financial year.

2. Simulation and development phase

Options to overcome the above issues have been developed, simulated to ensure their usefulness and will be canvassed amongst stakeholders. During 2014/15 standards and specifications have been finalised and are currently being reviewed by the appropriate stakeholders to ensure compatibility with the existing network infrastructure and operations. Internal guidelines for general use within Essential Energy's network area are currently being developed; this work is scheduled for completion during the 2015/16 financial year.

3. General deployment phase

The utilisation of distribution capacitors as an alternate technology for demand reductions on Essential Energy's distribution network will require appropriate training through all levels of the supply chain as well as familiarisation with the appropriate specifications and guidelines on distribution capacitor bank usage. This training and education is currently underway and is planned for completion during the 2015/16 financial year.

6.8 Benefits

Through the completion of the Capacitor Package Development project, Essential Energy will build demand management capability and capacity, specifically in the application of distribution capacitors. In doing so distribution capacitors will become business as usual items for use in Essential Energy's network area.

The use of distribution capacitors offers significant benefits to voltage, peak demand and loss reduction as shown in the examples below;

Example 1.

Peak load before any recent augmentation on the Clarencetown feeder out of Dungog Zone Substation (top of picture) was approximately 4.9 MVA, with 2MVA supplying the Clarencetown load some 30km from the Zone Substation through three series regulators.

Concerns were raised over low voltage issues before the first and second regulators as well as over the thermal capacity of the mainline through to Clarencetown.

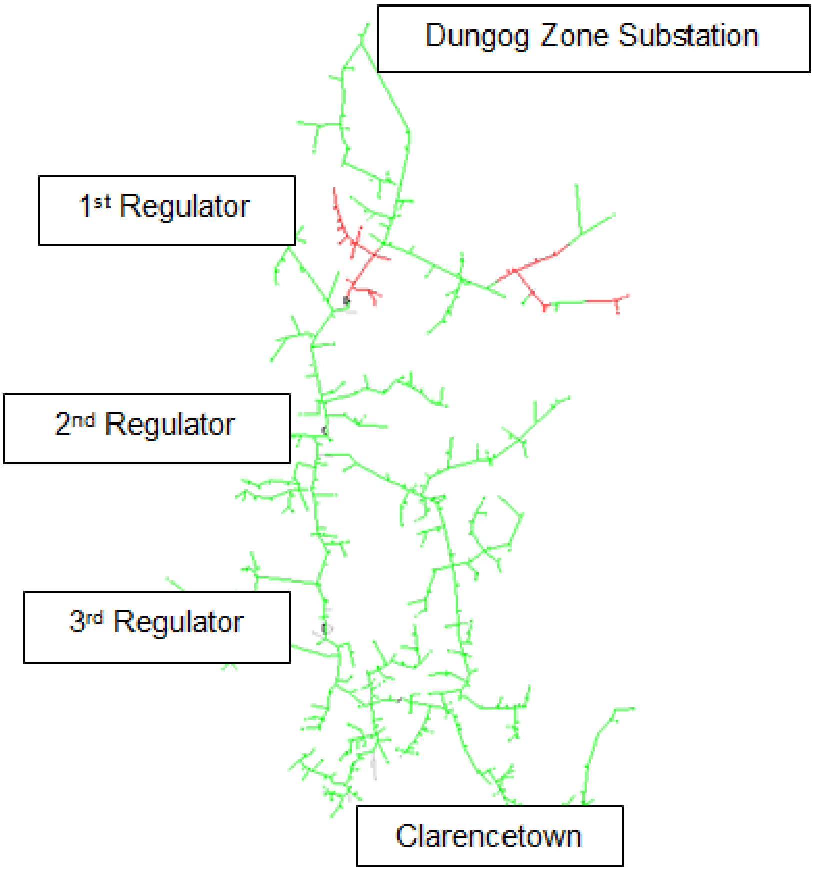


Figure 15: Example Capacitor Installation 1

The table below shows the benefits of installing two 300kVAr capacitor banks in Clarencetown.

Table 4: Example Capacitor Installation 1

	Original	2x 300kVAr Capacitor Banks	Unit reduction
ZS kVA	4,911	4,360	551
1st regulator kVA	3,802	3,470	332
2nd regulator kVA	3,227	2,971	256
3rd regulator kVA	2,065	1,943	122
Minimum Voltage p.u.	0.89	0.91	-0.02
Losses (peak) kW	853	688	165
Estimated annual losses (MWh)	2,241	1,808	433

Example 2.
Peak load before any recent augmentation on the Tathra feeder out of Bega Maher St Zone Substation (top of picture) was approximately 4.2 MVA, with 2MVA supplying the Tathra load at the end of the feeder (split into northern and southern feeder legs) some 20km from the Zone Substation.

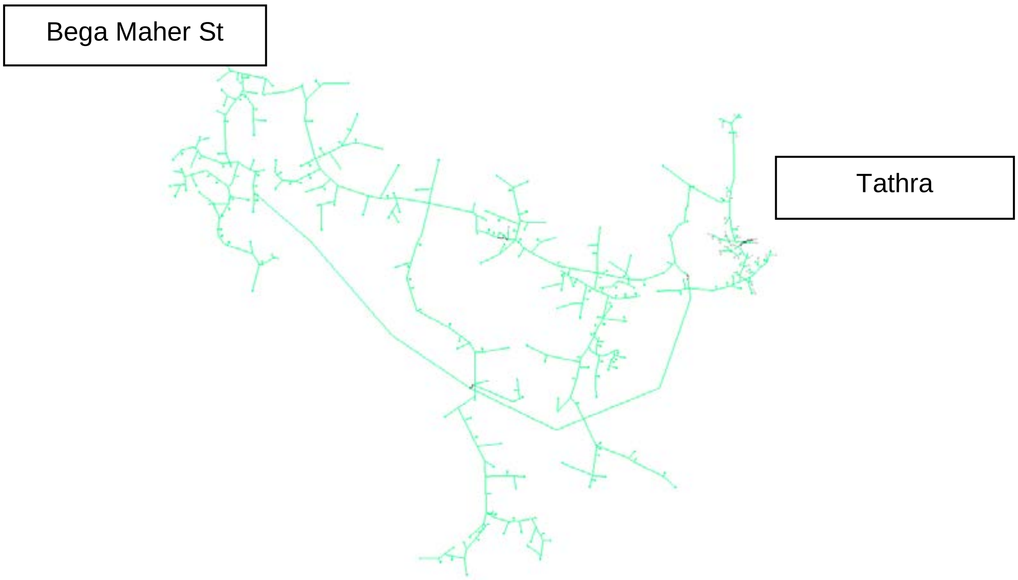


Figure 16 - Example Capacitor Installation 2

The table below shows the benefits of installing two 300kVAr capacitor banks in Tathra.

Table 5 - Example Capacitor Installation 2

	Original	2x 300kVAr Capacitor Bank	Unit reduction
ZS kVA	4,225	3,942	283
Regulator kVA	1,455	1,350	105
Northern Tathra kVA	749	678	71
Southern Tathra kVA	1,344	1,212	132
Minimum Voltage p.u.	0.95	0.98	-0.03
Losses (peak) kW	209	181	28
Estimated annual losses (MWh)	549	476	74

7 Switched Reactors

Figure 17: Nyngan SWER Switched Reactor

7.1 Summary

The switched reactor project has been developed to reduce reactive power demands in single wire earth return (SWER) systems thereby reducing the network voltage swing, reducing loses, reducing the need for larger isolation transformers, deferring or removing the need for augmentation and lowering the cost of supply to customers.

7.2 Background information

Single wire earth return (SWER) feeders are a highly cost effective method of distributing power over large areas with low load density, however due to their long line length the augmentation cost for SWER feeders can be prohibitively high for the load served.

One issue with SWER systems is their propensity for voltage rise due to charging currents, long line lengths and high impedance of the conductors and supplying source. In order to counteract charging currents shunt reactors are applied to the SWER feeder, thereby reducing line losses and minimizing isolation transformer sizes. Essential Energy has approximately 340 SWER lines and 250 reactors in service.

Reactors allow voltages to be reduced to acceptable levels and a reduction in line losses at low load periods; however as the network demand increases voltages can be brought down below acceptable levels during high load periods, thus the need for augmentation arises as the voltage envelope is pushed further and further between voltage rise at low load periods and low voltage at high load periods.

7.3 Switched Reactors project overview

In 2012/13 Essential Energy signed a memorandum of understanding and began consultation with an external university based research group with strong industry ties to evaluate potential methods of deferring expenditure on SWER feeders.

Augmentation expenditure on SWER feeders is largely related to voltage swing as described in section 7.2 or thermal limitations through the isolation transformer. The technical analysis was completed by the university group which included equipment such as capacitor banks, switched reactors and statcoms and reviewed by Essential Energy, whilst the analysis of the costs and benefits was completed by Essential Energy. The outcome of this analysis was that switched reactors would provide the most cost effective solution when taking into account the longer term benefits of decreased losses and reduced upstream demands.

In 2013/2014 Essential Energy placed an order for 5x switched reactors to trial in a constrained location and began development of the product with the manufacturer, during this period a number of revisions were made. Since this time substantial work has been completed, including finalising the unit design, completion of factory acceptance testing, integration to Essential Energy's SCADA system, completion of site designs, and completion of installation and commissioning procedures at the switched reactor sites. Figure 18 presents the results of the 'Notch' test during the field commissioning phase, where '1' on the right vertical axis corresponds to the switch in the closed position (reactor in service) and '0' the open position (reactor out of service).

Data collection and analysis commenced late 2014/15, with the expectation that should the anticipated benefits be reached at an efficient cost, then Essential Energy will go to market with a specification potentially mid 2015/16.

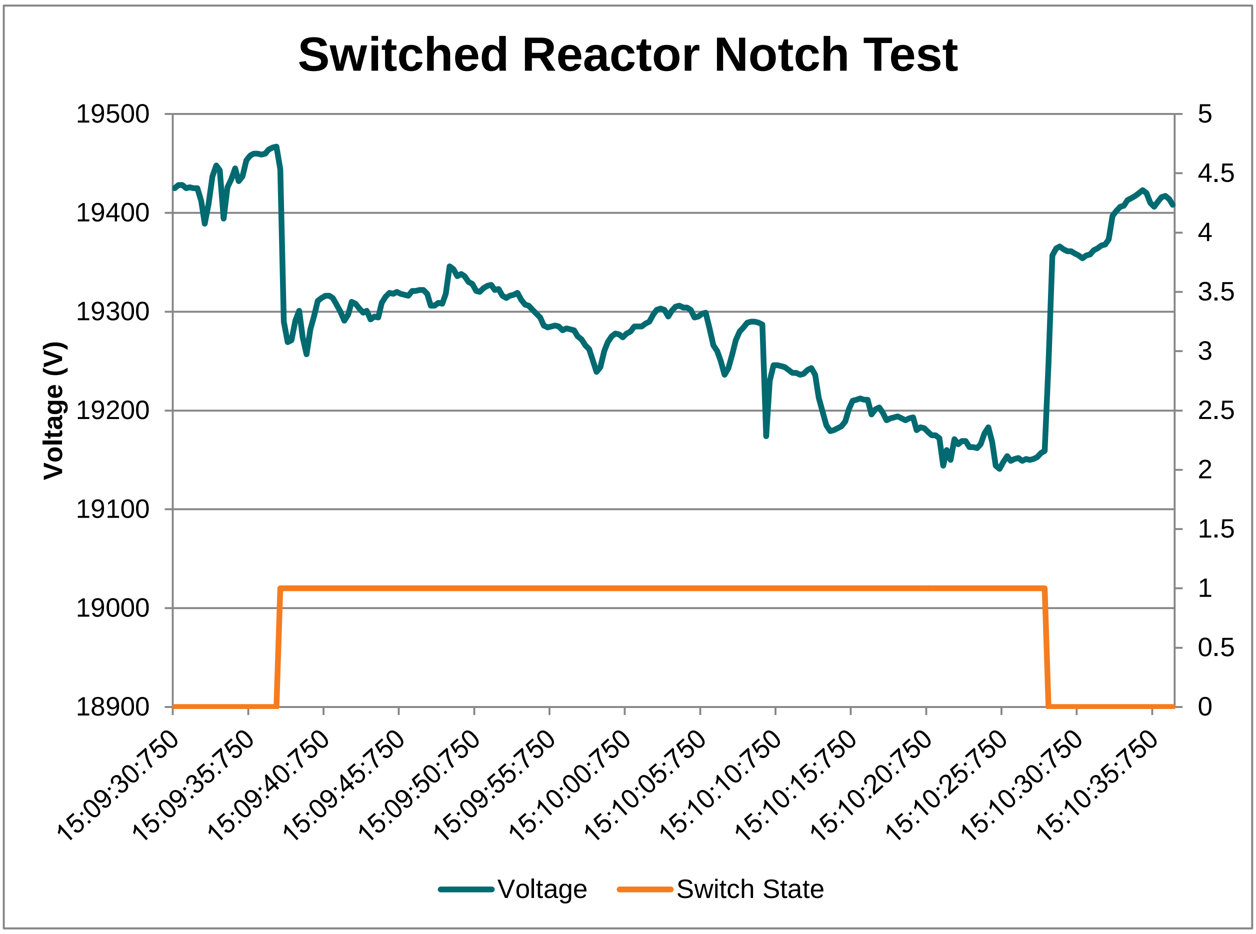


Figure 18: Switched Reactor Notch Test

7.4 Nature and Scope

The switched reactor project is a non-tariff based project involving the combination of two existing, widely used pieces of equipment (reactors and switches) with the addition of specifically developed control algorithms and ancillary technology.

The scope of the project is limited to;

- Design, modelling and simulation of SWER networks to investigate the effect of new equipment proposals on the energy capacity and delivered power quality;
- Estimation of costs and benefits
- Conceptualize, design, simulate and investigate the proof of concept equipment.
- Purchase of the equipment to carry out field trials
- The physical installation
- Test and field trial verification of equipment
- Project analysis including suggested paths to business as usual programs if proven viable

7.5 Aims and Expectations

The switched reactor project aims to develop knowledge and confidence in the application of controlled switching to SWER line reactors, this knowledge developed will include the following areas;

- The physical installation
- The configuration of the controls
- The operational aspects
- The network impacts
- The estimated package costs

As well as provide confirmation on the cost effectiveness of reducing peak demand through the use of switched reactors.

7.6 Selection

Given the information sought (set out in section 7.5), specific to Essential Energy's network area the following options were considered;

1. Customer based power factor correction

Customer based power factor correction can be some of the cheapest demand reductions available , however customer based power factor correction is not particularly relevant to SWER feeders for a number of reasons including;

- Individual customers on SWER feeders generally have relatively low individual demands and therefore due to the applicable tariffs, minimal financial incentive to install power factor correction equipment or more generally control their network demands. Essential Energy does not currently believe that relatively low demand or energy usage customers have enough information to enable the use of appropriate demand based tariffs.
- Customer based power factor correction may help correct voltage issues at high loads, however it has little reference to power factor of the line when the power factor is caused by capacitive charging currents

Therefore this was not the preferred solution.

2. Embedded Generation with/without energy storage

Uncontrolled embedded generation is unable to reliably provide the peak demand reduction / voltage control required. Controlled embedded generation in the form of a controlled generator or with energy storage can meet the requirements of the project, however the indicative costs are much higher than the preferred solution with little reduction in reactive power flows. Therefore this was not the preferred solution.

3. Capacitor banks

Capacitor banks can be used to control voltage levels on SWER feeders if this is the primary concern, however due to the nature of SWER feeders and the capacitive charges present on such feeders they will also tend to increase currents and losses along the SWER feeder. Therefore this was not the preferred solution.

4. Switched reactors

Reactors already exist on the Essential Energy network and have relatively few issues, their standard sizing allows for distributed locations, which in turn provides the greatest reduction in losses and demand, they are connected to the HV and therefore can be controlled directly from the HV voltage and or power factor. For these reasons switched reactors were the preferred solution.

7.7 Implementation

The switched reactor project can be defined as three distinct stages;

1. Simulation and Development

In 2012/13 Essential Energy began consultation with an external university based research group with strong industry ties to evaluate potential methods of deferring expenditure on SWER feeders.

The technical analysis was completed by the university group which included equipment such as capacitor banks, switched reactors and statcoms and reviewed by Essential Energy, whilst the analysis of the costs and benefits was completed by Essential Energy. The outcome of this analysis was that switched reactors would provide the most cost effective solution when taking into account the longer term benefits of decreased losses and reduced upstream demands.

In 2013/2014 Essential Energy placed an order for 5x switched reactors to trial in a constrained location and began development of the product with the manufacturer, during this period a number of revisions were made. Since this time substantial work has been completed, including finalising the unit design, completion of factory acceptance testing, integration to Essential Energy's SCADA system, completion of site designs, and completion of installation and commissioning procedures at the switched reactors sites.

2. Implementation and Evaluation

In 2014/15 the switch reactors were installed and commissioned in the field, permitting commencement of the data collection and analysis phase. These units will remain in situ for a minimum of 12 months in order for both Essential Energy and the manufacturer to evaluate the benefits, workings and any required improvements to the device.

3. General deployment phase

Should the anticipated benefits be reached at an efficient cost, then Essential Energy will evaluate the potential broader scale implementation of switched reactors and go to market with a specification potentially mid 2015/16.

7.8 Benefits

Due to the project being in the initial stages, with the field installation completed late 2014/15, minimal project benefits have been delivered, however a number of anticipated benefits are highlighted below;

- Confidence in the use of innovative technology solutions such as switched reactors which may then be used to meet legislated power quality standards more efficiently than traditional network investment or as a means of deferring network investment.
- Understanding of the control structures available for switching of a tool kit of network elements and their relative costs, benefits and issues
- A tool for use in the economic deferral of network investment, through the reduction of demand and losses.
- Avoid network augmentation through reducing/limiting peak demand and improved power quality
- Increase end use efficiency and equipment life
- Decrease network losses
- Facilitating the integration of distributed generation into the grid
- Improve power factor
- Improving network visibility via remote monitoring and control

8 Compliance Summary

As per section 3.1.3 of the Determination, projects under the DMIS must meet the following criteria;

1. Demand management projects or programs are measures undertaken by a DNSP to meet customer demand by shifting or reducing demand for standard control services through non–network alternatives, or the management of demand in some other way, rather than increasing supply through network augmentation.

2. Demand management projects or programs may be:
   a. broad–based demand management projects or programs—which aim to reduce demand for standard control services across a DNSP's network, rather than at a specific point on the network. These may be projects targeted at particular network users, such as residential or commercial customers, and may include energy efficiency programs; and/or reduce demand for standard control services across a DNSP's network, rather than at a specific point on the network.
   b. peak demand management projects or programs—which aim to address specific network constraints by reducing demand on the network at the location and time of the constraint.

3. Demand management projects or programs may be innovative, and designed to build demand management capability and capacity and explore potentially efficient demand management mechanisms, including but not limited to new or original concepts.

4. Recoverable projects and programs may be tariff or non–tariff based.

5. Costs recovered under this scheme:
   a. must not be recoverable under any other jurisdictional incentive scheme,
   b. must not be recoverable under any other state or Australian Government scheme, and
   c. must not be included in forecast capital or operating expenditure approved in the distribution determination for the next regulatory control period, or under any other incentive scheme in that determination.

6. Expenditure under the DMIA can be in the nature of capex or opex. The AER considers that capex payments made under the DMIA should be treated as capital contributions under clause 6.21.1 of the NER and therefore not rolled into the regulatory asset base at the start of the subsequent regulatory control period. However the AER's decision on the treatment of capex will only be made as part of the subsequent distribution determination.

Section 3.1.4.1 of the Determination requires that each ACT and NSW DNSPs must submit to the AER annual reports on their expenditure under the DMIA for each regulatory year.

The following table provides the details of Essential Energy's DMIA projects undertaken in the 2014/15 financial year as outlined above.

Table 6 - Details of Essential Energy's DMIA projects undertaken in the 2014/15 financial year

Name of Project	The projects outlined meet the DMIA criteria under the following conditions;						
	1. Meets demand needs other than through increasing network supply through augmentation ?	2a. Relevant to broad–based programs?	2b. Relevant to specific network constraints?	3. Innovative? Designed to build demand management capability and capacity? Explores potentially efficient demand management mechanisms?	4. Is the project tariff or non–tariff based/	5. Yes/No, the costs allocated to the project are; a/b. not recoverable under any other jurisdictional, state or Australian Government scheme c. not be included in forecast capital or operating expenditure	6. Is the expenditure capex or opex in nature?
Grid Interactive Inverter program 20kVA based	Yes	Possibly	Yes	Yes	Non-tariff	Yes	N/A
Grid Interactive Inverter program 5kVA based	Yes	Yes	Yes	Yes	Non-tariff	Yes	Capex
Conservation Voltage Reduction through low voltage regulators	Yes	Possibly	Yes	Yes	Non-tariff	Yes	Capex
Capacitor Package Development	Yes	Possibly	Yes	Yes	Non-tariff	Yes	N/A
Switched Reactors	Yes	Possibly	Yes	Yes	Non-tariff	Yes	Capex